VOLATILE COMPOUNDS AS ATTRACTANTS FOR *CAMPSOMERIS TASMANIENSIS* (SAUSSURE) (HYMENOPTERA: SCOLIIDAE)

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Abstract
Japanese-beetle traps baited with anethole attracted 17.9 times more adults of *Campsomeris tasmaniensis* than did unbaited traps. Phenol attracted 7.1 times, hexan-1-ol attracted 6.4 times, and eugenol, n-butyric acid, 1-nonanol and sorbic acid attracted 3-4 times more *C. tasmaniensis* than did unbaited traps. Geraniol did not attract the wasps. Anethole-baited traps at or near the height of the crop were the most attractive. *C. tasmaniensis* populations can be monitored with anethole-baited traps.

Introduction
The use of food-related compounds as lures for scarab beetles has been encouraged by their attractiveness to Japanese beetle *Popillia japonica* Newman (Ladd and Klein 1982). While testing such compounds as lures for cane beetles (melolonthines) in southern Queensland, I caught adults of the yellow flower wasp *Campsomeris tasmaniensis* (Saussure). This wasp occurs from New Guinea, through eastern Australia to South Australia, with a few records from inland and north-western Australia (I.D. Naumann, *pers. comm.*). *C. tasmaniensis* parasitises canegrubs and similar scarab larvae (Illingworth 1921; Jarvis 1929), and pollinates flowers, including macadamias (Vithanage and Ironside 1986). This paper records the effectiveness of some volatile compounds as attractants for *C. tasmaniensis*, and determines the optimum height for anethole-baited traps.

Materials and Methods
I exposed lures in Catch-can® Japanese-beetle traps (Trécé Inc., Salinas) near Bundaberg, south-eastern Queensland. Lures evaporated from 900 mm pieces of sponge placed in the same position in the trap as the standard Trécé lure. Every 2-3 d, I counted wasps, rebaited traps with 5 mL of lure, and re-randomised the traps. Both sexes of *C. tasmaniensis* were caught, but separate counts were not made.

For 28 d from 24 September 1990, I tested the following compounds as lures: phenol (Univar, >99% pure); hexan-1-ol (Unilab, >99% pure); 1-nonanol (Fluka, >98% pure); anethole (1-methoxy-4-(1-propenyl)benzene, Fluka, >98% pure); geraniol (3,7-dimethyl-2,6-octadien-1-ol, Fluka, 96% pure); eugenol (2-methoxy-4-(2-propenyl)phenol, Fluka, >98% pure); sorbic acid (2,4-hexadienoic acid, Unilab, >98.5% pure); n-butyric acid (Unilab, >99% pure). Saturated aqueous solutions of phenol and sorbic acid were used; other lures were not diluted. Three replicates of the eight lures and an unbaited control were placed in a randomised-block design in a recently-harvested sugarcane field. Traps were hung 1 m above ground and 10 m apart. Wasps were counted 12 times.

For 17 d from 26 October 1990, from 24 December 1990, and from 4 February 1991, I tested the effect of height on the attractiveness of anethole-baited traps. Traps were hung 0.5, 1, 1.5 and 2 m above ground and were placed 10 m apart. Four replicates were placed in a randomised-block design in a field of sugarcane 0.3-0.4 m high in October-November, 1.3-1.5 m high in December-January, and 2.0-2.2 m high in February. Wasps were counted seven times in each test.

In all experiments raw and ln(x+1) transformed counts in most treatments were not normally distributed ($P<0.01$, Wilk-Shapiro test). I used a Friedman non-parametric analysis of variance with each of the counts as a separate observation per experimental unit (Conover 1980). Mean ranks were compared using the inequality method (Conover 1980).

Results and Discussion

There were highly significant differences in the attractiveness of the different compounds to *C. tasmaniensis* ($T = 75.45$, df = 8, $P < 0.001$). Anethole-baited traps attracted 17.9 times more wasps than did unbaited traps ($P < 0.001$), and significantly ($P < 0.05$) more wasps than did any other lure (Table 1). Traps baited with phenol solution attracted 7.1 times more wasps, and those with hexan-1-ol 6.4 times more wasps than did unbaited traps ($P < 0.001$, Table 1). Catches of *C. tasmaniensis* in traps baited with eugenol, n-butyric acid, 1-nonanol or sorbic acid solution were significantly ($P < 0.05$) higher than catches in unbaited traps (Table 1). Geraniol did not attract *C. tasmaniensis.*

Anethole is also attractive to the Australian scarabs *Phyllotocus navicularis* Blanchard, *Eupoecila australasiae* (Donovan) and *Liparetrus atriceps* Macleay (Allsopp and Cherry 1991a; Allsopp 1992) and to honey bees *Apis mellifera* L. (Ladd *et al.* 1974; Allsopp and Cherry 1991b). These species and *C. tasmaniensis* are attracted to flowers and feed on nectar. Anethole commonly occurs in plant oils and hexan-1-ol is found in seeds and fruits (Windholz 1983). Their presence may enhance the attractiveness of plants to nectar-feeding species.

Phenol is an unlikely attractant, as it is poisonous and caustic (Windholz 1983). However, it does attract males of the New Zealand grassgrub *Costelytra zealandica* (White) (Henzell and Lowe 1970).

In the October-November height test, anethole-baited traps 1 m high attracted significantly ($P < 0.05$) more wasps than did traps 1.5 or 2 m high (Table 2, $T = 9.80$, df = 3, $P < 0.025$). There was no significant difference in the attractiveness of traps at 0.5 and 1 m above ground. In December-January, traps 2 m high attracted significantly ($P < 0.05$) more wasps than did traps 0.5 or 1 m high (Table 2, $T = 14.46$, df = 3, $P < 0.005$), but not significantly more than traps 1.5 m high. In February, traps 2 m high attracted significantly ($P < 0.001$) more wasps than did lower traps and traps 1.5 m high attracted more wasps ($P < 0.05$) than traps at 0.5 m (Table 2, $T = 45.19$, df = 3, $P < 0.005$).

The most attractive traps were those at or near the height of the crop canopy. Traps within the crop may be less attractive because only a short vapour plume forms. Alternatively, *C. tasmaniensis* may fly at about the canopy

Table 1. Catches of *Campsomeris tasmaniensis* at traps baited with lures

Lure	Mean rank*	Number/trap/period
Anethole	96.1 a	3.83
Hexan-1-ol	75.6 b	1.38
Phenol	71.0 bc	1.52
Eugenol	62.2 cd	0.88
n-Butyric acid	59.4 cd	0.67
1-Nonanol	56.4 d	0.83
Sorbic acid	56.1 d	0.62
Geraniol	51.7 de	0.40
Unbaited	43.1 e	0.21

* Means followed by the same letter are not significantly different at the 5% level.

level, or only those wasps flying at the canopy level are foraging and receptive to food lures; others may be host searching near to the ground and not receptive to anethole. If all *C. tasmaniensis* fly at the canopy level, it poses the conundrum: can *C. tasmaniensis* locate host scarab larvae in the soil from a height of up to 2 m and through a dense crop canopy; or do they only parasitise larvae in fields that are bare or have low crops? This could be resolved by monitoring parasitism of canegrubs in fields with sugarcane at different heights.

Table 2. Catches of *Campsomeris tasmaniensis* in anethole-baited traps at different heights

Trap height (m)	October-November		December-January		February	
	Mean rank*	No./trap /period	Mean rank*	No./trap /period	Mean rank*	No./trap /period
0.5	16.0 ab	0.36	11.1 c	0.07	10.6 c	0.00
1.0	16.6 a	0.46	13.5 bc	0.32	12.3 bc	0.14
1.5	13.4 bc	0.14	16.1 ab	1.11	13.8 b	0.32
2.0	12.0 c	0.04	17.3 a	1.00	21.3 a	2.04

* Means within a column followed by the same letter are not significantly different at the 5% level.

Anethole-baited traps hung at the level of the crop canopy offer a method for monitoring populations of adult *C. tasmaniensis* in studies on the occurrence and effectiveness of the parasite in sugarcane fields. Optimisation of trap design may improve trapping efficiency.

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